2008
Systems Analysis
Summary of Annual Merit Review Systems Analysis Subprogram

Summary of Reviewer Comments on Systems Analysis Subprogram:

The reviewers considered the Systems Analysis Subprogram an essential component to the Hydrogen Program mission and critical to the President's Hydrogen Fuel and Advanced Energy Initiatives. The projects are considered appropriately diverse and focused on addressing technical barriers and meeting targets.

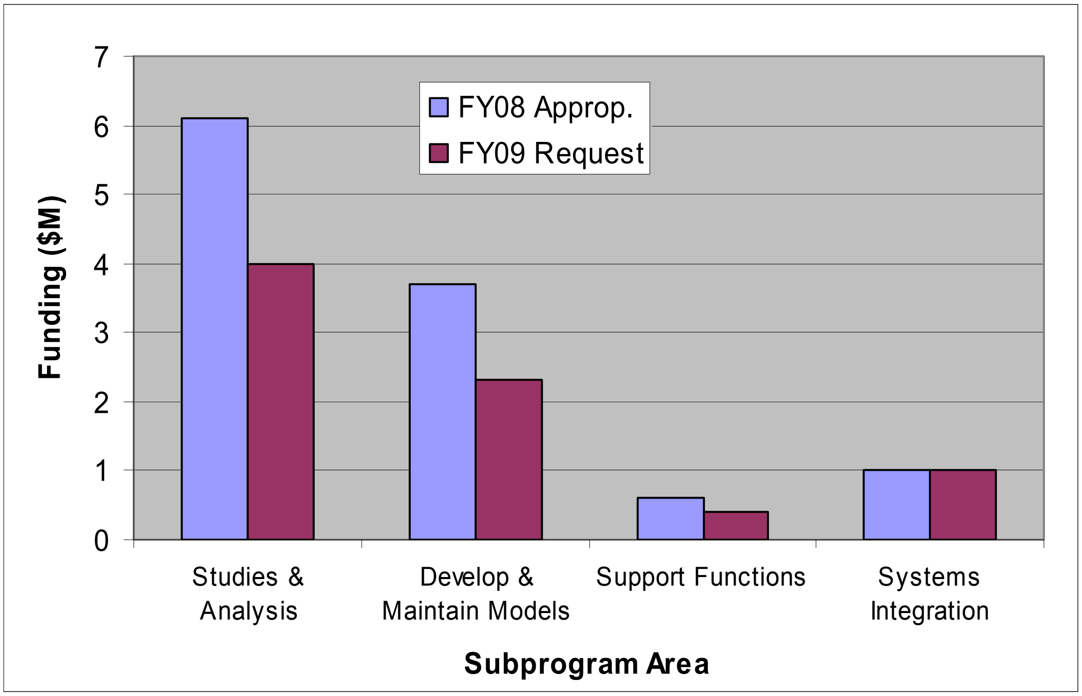
In general, the reviewers noted that Systems Analysis is a complex subprogram but is receiving the appropriate management attention. Some reviewers commented that the subprogram is well managed and has adopted an organized approach for analytical support of the Hydrogen Program, which is appropriate for addressing the comprehensive list barriers identified the Multi-Year Research, Development and Demonstration Plan (MYPP).

Recommendations identified by the reviewers for Systems Analysis were: 1) a summary of assumptions should continue to be provided at the beginning of the Annual Merit Review for the Analysis Session; 2) a model discussion and demonstration should be provided prior to the Annual Merit Review for the Analysis Session; 3) fuel purity and the impact on performance and cost tradeoff analysis should continue; and 4) model validation and peer review is critical for sound and credible analysis. The Systems Analysis subprogram will continue to address these issues and reviewer feedback will be incorporated in the Systems Analysis Plan.

Finally, the reviewers commented that the analysis and model portfolio was complete and making good progress in addressing analysis topics. They indicated the analysis MYPP barriers were being addressed by the Systems Analysis subprogram and put into the proper perspective.

Systems Analysis Funding:

The funding for Systems Analysis primarily includes model development and analysis required for meeting the Hydrogen Program's technology readiness goal to enable commercialization of transportation fuel cell vehicles as well as model development and analysis for early market applications. The 2009 request-level funding profile, subject to Congressional appropriation, addresses the National Academies' Report recommendations and provides greater emphasis on transition, resource, and infrastructure analysis.



Majority of Reviewer Comments and Recommendations:

In general, the maximum, minimum and average scores of the reviewers of the Systems Analysis projects were 3.9, 2.6 and 3.2, respectively. Reviewers commented that the diversity of the Systems Analysis project portfolio addresses the "analysis and modeling gaps" of the subprogram, and the resource, infrastructure, transition and early market analysis requirements. The major recommendations for the Systems Analysis projects are summarized below. The Systems Analysis subprogram will address these recommendations.

Model Development: Projects in model development received very favorable reviews. The majority of the projects were regarded as well-aligned with the current program goals and objectives. Reviewers consistently suggested the models be peer reviewed and validated with industry, academia and the National Laboratories. Reviewers recommended that models use a consistent set of inputs and assumptions; include plug in hybrid electric vehicles for well to wheel analysis of petroleum use and greenhouse gas emissions; and integrate the stationary power generation and transportation sectors.

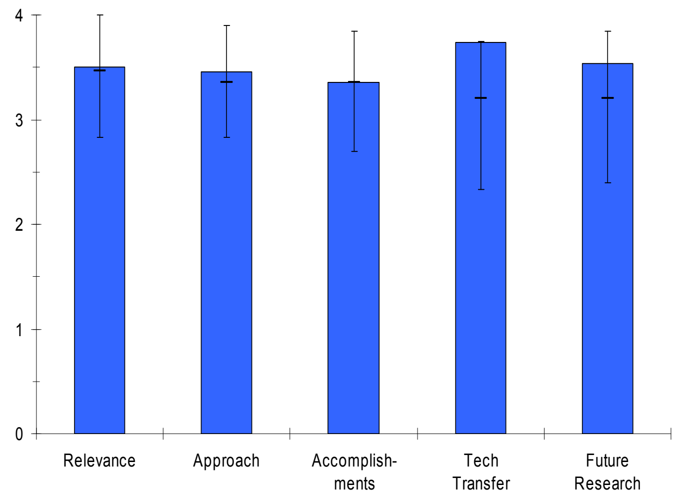
Program Analysis: The analysis projects were consistently ranked as good and the analysis projects supported the program goals. In general, the reviewers concurred that the analysis projects need to be peer reviewed prior to issue and publication, and that a consistent set of inputs and assumptions be used. The reviewers felt that the Lawrence Livermore National Laboratory (LLNL) Water Analysis project is important for hydrogen production but should be extended to include analysis of renewable hydrogen production pathways. The resource and infrastructure analysis with the new Hydrogen Demand and Resource Analysis Tool (HyDRA) was well received and encouraged by reviewers. The reviewers acknowledged that the environmental projects with University of Illinois and Tetra Tech, which are just getting started, are important to the Hydrogen Program in understanding how hydrogen production and use will affect the upper atmosphere and the environment. The TIAX platinum availability and leasing strategy project and the Argonne National Laboratory hydrogen quality project received good reviews and their importance was recognized in addressing fuel cell cost and performance.

Lessons Learned Analysis: In general, the reviewers agreed that understanding lessons from previous efforts to introduce new alternative fuels and power generation systems is important for developing a successful strategy to introduce hydrogen as a transportation fuel and fuel cells for stationary and transportation power. Use of a "lessons learned" analysis enables an understanding of past early market penetration issues which may be relevant to hydrogen production and fueling applications. Reviewers acknowledge the benefits of including industry in the analysis process.

Project # AN-01: HyTrans Model: Analyzing the Transition to Hydrogen-Powered Transportation
David Greene; ORNL

Brief Summary of Project

Overall Project Score: 3.5 (5 Reviews Received)



The objectives of this project are to 1) complete development of an integrated market model of the hydrogen transition; 2) construct and publish credible scenarios of the transition to hydrogen fuel cell vehicles; 3) collaborate with the International Partnership for the Hydrogen Economy/International Energy Agency to develop joint European Union and North America transition scenarios; 4) analysis the potential for a federal acquisition program to establish a sustainable North American non-automotive proton exchange membrane fuel cell industry; and 5) update and improve the HyTrans integrated market model. In fiscal year 2008, Oak Ridge National Laboratory is focusing on disseminating the results of the transition scenarios establishing international partnerships and building towards future assessments.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Project objectives and intended results are consistent with DOE Hydrogen economy vision and related goals.
- Very good. Accurately summarizes the plight of the small non-transportation PEM manufacturer. Small companies, like Plug, ReliOn or Idatech, cannot continue to subsidize the price and remain solvent. These small units would probably use the same balance of plant hardware as the vehicles. Demand from either sector would be insufficient for a manufacturer to develop new, low cost components (valves, sensors, connectors, etc.). However, similar demand from the transportation sector and the stationary sector may generate enough demand to justify the manufacturer's investment and risk.
- This is a key component of the modeling and analytical work supporting hydrogen-related decisions by the Department of Energy and many other organizations.
- Dr. Greene and his associates continue to develop extensive, credible, and practical results through their sophisticated, "world-class" analytical activities.
- This project and model are extremely relevant.
- It is very important that the Program understand the transition from hydrocarbon to hydrogen.
- Resolving the chicken or egg issue is critical.
- Presented a good picture of what the vehicle roll-out transition looks like and the potential impacts during the transition period.
- Evaluate if the federal acquisition model is realistic for non-OEM PEM fuel cell manufacturers. Information appears to be preliminary and many assumptions have been made about fuel cell costs, durability, and the synergistic aspect of the private non-OEM companies working together.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- The technical strategy and approach to developing predictive analyses for phased transition from a hydrocarbon to a hydrogen economy is certainly challenging; the present work contributes to an understanding of issues and opportunities to some extent. The work is on-going. As of now the results are comprehensible and meaningful.
- The model results place the entire acquisition burden on the federal government; it does not identify government-private sector partnership. Issues on the program development, out-year funding requests, etc., for the massive acquisition process, etc., are not discussed. Although the study concludes that a transition to a H_2 economy is entirely a federal government responsibility, summary-level reports on why so and implementation approaches for policy and Deputy Assistant Secretary level readers are needed.
- The approach is very good. The polling of industry members was warranted. The polling does not appear to be as extensive as it might have been.
- The most advanced, state-of-the-art analytical and modeling methodologies are well understood and used by Dr. Greene.
- Prior work related to vehicle applications is now being extended to stationary hydrogen fuel cell applications in support of market transformation initiatives.
- The potential for hydrogen fueled internal combustion vehicle commercialization should be considered in the project approach. This is recognized by Dr. Greene.
- Market simulation to understand cause and effect will enable much better planning of research and development and the transition to commercialization.
- International collaboration is necessary because the hydrogen economy will be international.
- Developing and encouraging other PEM applications should help commercialization for transportation.
- The project approach appears a bit fragmented from the slides. Project covers HyTrans model as well as non-OEM fuel cell aspect.
- Dr. Greene needs to take a closer look at the uncertainties in the model.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.4** based on accomplishments.

- Significant progress toward accomplishing task goals has been completed or is in progress.
- The project's technical accomplishments and progress toward project goals is good. The modeling is interesting; assumptions are not noted.
- Information on many milestones and accomplishments was provided.
- These milestones and accomplishments include significant analytical and modeling results (e.g. HyTrans), reports, testimony based on analytical work, and responses to specific needs of the hydrogen program.
- Development of cost models plus greenhouse gas (GHG) impacts is impressive.
- The growth from 2000 units/yr federal acquisition to 35,000 units/yr federal plus private acquisition is encouraging.
- Need to further refine and/or update the HyTrans model based on updated versions of other models (H2A, GREET) to obtain more representative results.
- Need to look at what effect the success in automotive fuel cells (tougher cost & lifetime goals) might have on non-automotive fuel cell systems and the level of interdependency.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.7** for technology transfer and collaboration.

- National labs, two major auto manufacturers, fuel cell manufacturers, and universities are involved in this important, hydrocarbon-to-hydrogen energy technology transition study and analysis of issues, barriers, needs, and opportunities. The highly competent team with complementary expertise will make the study results meaningful and useful to decision makers.
- The project has good technology transfer/collaboration. The attempts to engage industry are laudable. The engagement of California Air Resources Board is important.
- Working with the Europeans shows a global focus.
- Dr. Greene's collaborations with others, both nationally and internationally, are extensive.

- The work on this project is done in the context of well-established partnerships and on-going communications/joint development work with colleagues in other national laboratories, industry, and many government organizations. Many were included in the presentation.
- Interactions with the international community, industry, and other research organizations are exceptional.
- Excellent work with other models and various public and private agencies.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.5** for proposed future work.

- The proposed future work is conducive to expanding the scope of the analyses.
- However, the analysis assumes that PEM will dominate the market; assumes that PEM material(s) has achieved commercial/market readiness. This assumption is not entirely correct.
- The analysis assumes that hydrogen is the safest fuel. Thus, the analysis does not address the safety and environmental issues for the hydrogen economy scenario from cradle to grave, that is the safety and environmental issues from the production of hydrogen to its end uses.
- The project's approach to and relevance to proposed future research is good.
- An excellent summary and discussion of future plans was provided.
- Planned work is appropriate for bringing this work to a worthwhile and useful conclusion.
- The PI is on the right track.

Strengths and weaknesses

Strengths
- Technical, policy, and program management readers will get insights and understanding on the issues related to hydrogen energy technology deployment scenarios.
- The project's outreach to major OEMs and fuel cell manufacturers is a strength.
- A strong, experienced, committed analytical team led by Dr. Greene. It is highly respected for its body of analytical work, its expertise, and its responsiveness.
- The project has the strength of an excellent team with the right strategy.
- Incorporation of various models provides a good picture of hydrogen transition period.

Weaknesses
- The analysis depends on three private sector entities to determine that hydrogen energy technology R&D and related marketing efforts are all federal initiatives; opinions of federal and state policy makers should also have been included. Complementary technologies, such as hydrogen internal combustion engine, PEM material at its current state-of-the-art (i.e. its commercial readiness status), fuel dispensing, on-board and off-board storage, etc., have not been included in the study. Hydrogen sources, renewable, nuclear, fossil, comparative economics, etc., need to be included. Perhaps a comparison with battery powered vehicles, especially for local uses, along with its advantages and economics should also be included for a holistic approach to system studies.
- One purpose of system study is R&D guidance. Some prudent, mission-critical R&D needs and thrust should also be included.
- The project is missing the synergy on balance of plant hardware for both stationary and transportation applications.
- A huge gap between this federal acquisition and sustainable automotive production levels still remains, but Dr. Greene has plans to address this.

Specific recommendations and additions or deletions to the work scope

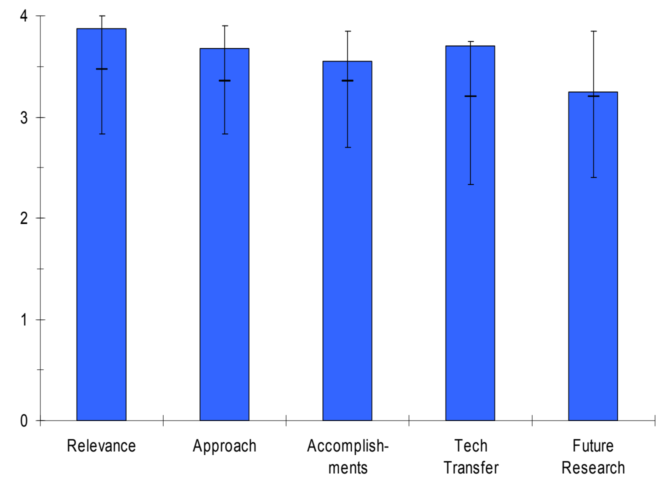
- The weaknesses section discusses the limitations of the model and, in turn, recommends additional studies to make the overall study comprehensible to both technical analysts and policy makers.
- In his presentation, the Ford presenter's slide included "(1) hydrogen fuel storage is a significant challenge and (2) economic viability is uncertain."

- This work should address such challenges and make the analyses results and any predictive models more comprehensive.
- Poll the smaller companies active in this arena (for example ReliOn, Idatech, Altergy, Bloom Energy, etc.) A more complete list can be obtained from A. Androsky of the USFCC.
- The approach to market transformation analysis could be extended to include an independent and more complete assessment of the nexus between fuel cell production capability and the timing of market demand.
- Expanding the outreach associated with the sustainable PEM fuel cells activity to companies beyond the three identified should be considered.
- A follow-up project or continuation of this project is needed to establish a viable path from federal acquisition of 1 kW to 5 kW fuel cells at 2000 units/yr to initial automotive production of 150,000 units/yr with power levels of 50 kW to 100 kW.
- Adding hydrogen fueled internal combustion engines as an additional element of market transition would be very helpful in establishing an understanding of the value/benefit of this for infrastructure transition.

Project # AN-02: GREET WTW Analysis Results and Comparison of Advanced Vehicle Technologies
Michael Wang; ANL

Brief Summary of Project

Overall Project Score: 3.6 (4 Reviews Received)



The objectives of this project are to 1) expand and update the GREET model for hydrogen production pathways and for applications of fuel cell vehicles (FCVs) and other fuel cell systems; 2) conduct well-to-wheels (WTW) analysis of hydrogen FCVs with various hydrogen production pathways; 3) conduct life-cycle analysis of hydrogen-powered fuel cell systems; 4) provide WTW results for Office of Hydrogen, Fuel Cells, and Infrastructure Technologies efforts on the Hydrogen Posture Plan and the Multi-Year Program Plan; and 5) engage in discussions and dissemination of energy and environmental benefits of hydrogen FCVs and other fuel cell systems. Data was obtained for hydrogen production pathways (open literature, H2A simulation results, process engineering simulations) as well as hydrogen FCVs and other systems (open literature, PSAT simulations, data from industry).

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.9** for its relevance to DOE objectives.

- This is a key component of the modeling and analytical work supporting hydrogen-related decisions by the Department of Energy and many other organizations.
- Dr. Wang and his team continue to build on their prior body of work to develop updated, credible, and highly regarded results.
- The objectives are essential to the provide projections and insights into the hydrogen pathway.
- GREET is used and respected throughout the community. It is imperative that it contain accurate models applicable to hydrogen fuel and fuel cells.

Question 2: Approach to performing the research and development

This project was rated **3.7** on its approach.

- The approach includes on-going activities to maintain and utilize current information on technologies of interest, simulation models, etc.
- Continuing to expand, update, and apply the GREET model is a major component of the project.
- Consideration should be given to confirming assumptions resulting from literature through discussions with knowledgeable individuals having "real-world" experience. This suggestion stems from the response to a question on assumptions about energy conversion efficiencies in stationary systems.
- Please clarify the data and the conditions for the calculations and the comparisons of calculated values versus measured ones.
- Approach is very good but it would be good to show how these models can be "validated" when possible.
- I am concerned that H2A and PSAT may not be validated for the simulations that are providing inputs to GREET. Unfortunately, they may still be the best available sources of information. Fortunately, where data is available, it is being used.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- Dr. Wang discussed GREET 1.8, which was released in March 2008.
- Fuel-cycle analysis of fuel cell forklifts and distributed power generation is being done in support of the hydrogen program's market transformation initiative. This should benefit government officials and others interested in acquisition of fuel cell technology. Dr. Wang presented the results of recent analysis.
- GREET is also being expanded to support analysis of hydrogen plug-in hybrid vehicles.
- Progress and additions to GREET are very impressive, but it is difficult to separate what has been accomplished with HFCIT funding and what has been accomplished through funding from other sources.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.7** for technology transfer and collaboration.

- Dr. Wang's work with others, both nationally and internationally, is extensive. He continuously coordinates with other modelers and analysts, such as those working on H2A, PSAT and HyTrans.
- GREET is widely used and referenced worldwide.
- Indicate the data distributions.
- The model has a high number of simulation users which is a good sign of technology transfer.
- ANL should be commended for making GREET available to anyone and everyone and supporting the many researchers that use it.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.3** for proposed future work.

- An excellent summary and brief discussion of future work plans was presented.
- Future work will include analysis of biomass to hydrogen production options, as well as fuel cell plug-in electric vehicles.
- Use the metric system rather than the English system for the Greet international users.
- The proposed future research is good even if program is scheduled to end this year.
- Proposed future work is a good list; especially the FC PHEV Well to Wheel analysis should be given very high priority.

Strengths and weaknesses

Strengths
- A strong, experienced, committed, and highly regarded Principal Investigator and supporting team.
- Large amount of comparisons for the various selections for the future scenario.
- Very good distribution of software development to the world for use.
- This will be one of the most valuable models in the next administration when attention to greenhouse gases will escalate.

Weaknesses
- No strategies on how to get feedback from all or any specific group of users about improving parameters and improving program accuracy calculations.
- There are so many pathways that need to be developed; maybe there should be a more visible prioritization process for selecting which ones to develop next.

Specific recommendations and additions or deletions to the work scope

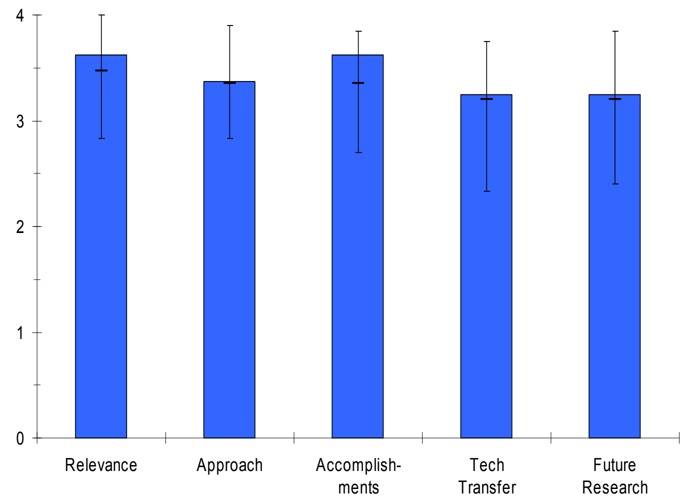
- It would be good to understand the diversity of the end users of the program and how to get their feedback on the program's prediction.
- Minor issue, but might consider deemphasizing work directed at FC forklifts in favor of fuel cell vehicle (FCV) model development, such as the proposed fuel cell (FC) plugin hybrid electric vehicle (PHEV)’s Well to Wheel analysis.

Project # AN-04: Macro-System Model
Mark Ruth; NREL

Brief Summary of Project

The overall objectives of this project are to develop a macro-system model (MSM) aimed at 1) performing rapid cross-cutting analysis utilizing and linking other models and improving consistency of technology representation; 2) supporting decisions regarding programmatic investments and focus of funding through analyses and sensitivity runs; and 3) supporting estimates of program outputs and outcomes. The 2007/2008 objectives are to 1) improve the structure of the MSM and develop a graphical user interface; 2) update versions of component models; 3) add stochastic analysis capability; 4) validate MSM results; and 5) begin interaction between MSM and spatial and temporal models.

Overall Project Score: 3.5 (4 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- The project's objective is very good by having a simpler, faster, user friendly model. Common definitions and equations across platforms is a must.
- Ambitious project, but could be very useful for overall Hydrogen Program planning.
- The scope of this project is extremely relevant to the needs of the DOE Program.
- Looking at all aspects of hydrogen transition period is critical to the success of the infrastructure/vehicle roll-out in the future.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- The project approach is very good. Designing a model that is compatible with other existing models is both cost-effective and wise.
- Need to be careful not to lose sight of the individual model assumptions. Some assumptions may not be reasonable, but setting up and running the Macro-System Model is a good way to identify (and hopefully change) those unreasonable assumptions.
- Technical approach is sound. The PI has focused on making the tool available to end users similar to what has been done for the H2A Model.
- Combining various models to look at technical, political, and environmental aspects to address key issues is a good approach.
- Need to consider making the model more user friendly since it is a different platform from other Excel-based models.
- Need to consider having more industry use/validation of the model.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- The technical accomplishments and progress are very good with the time and benchmarking in sync.
- Excellent progress has been made as shown by cost and performance results for various pathways.
- The PI is in the middle of the work plan and has demonstrated significant progress to date.
- More focus should be placed on making the model easier to use and making the list of assumptions used more explicit to the end user.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.3** for technology transfer and collaboration.

- The technology transfer/collaboration of the project is good. The collaboration seems to be limited to other national labs and Direct Technologies, Inc. (DTI). No mention was made of academic or industry input.
- The PIs close collaboration with other participants and institutions were evident in the presentation, and this is essential to the project.
- The project/model has exhibited excellent collaboration with other models developed at other national laboratories. However, more industry and independent use/validation is needed.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.3** for proposed future work.

- The approach to and relevance of proposed future research is good. Electrical costs and quality requirements should probably have been addressed earlier.
- Additional model validation is necessary and will be challenging.
- The project is on track and future work is well organized for a successful completion.
- Need to consider independent validation of model upon successful linking with other models. Solicit feedback from end-users for model improvement.

Strengths and weaknesses

Strengths
- Commonality with existing platforms was incorporated in the model.
- Harmonizing existing platforms was incorporated in the model.
- The project has accomplished very good work on a very challenging assignment.
- The high level Macro-System Model (MSM) development will be very useful to others conducting analyses on technologies and applications for the hydrogen economy. Attention is being paid to the user interface, but it is very important to complete the work so that end users outside of the host lab are able to easily access the model and use it. The PI is very qualified in the field.

Weaknesses
- There are some questions based on the assumed efficiency of the distributed steam methane reformers. How does the efficiency of a smaller distributed unit become greater than the efficiency of larger central units? Economy of scale would suggest that the central units are more efficient.
- Consideration should be given to making reformation of ethanol (C_2H_5OH) a lower priority.
- There was no mention of collaboration or benchmarking the results with industry users.

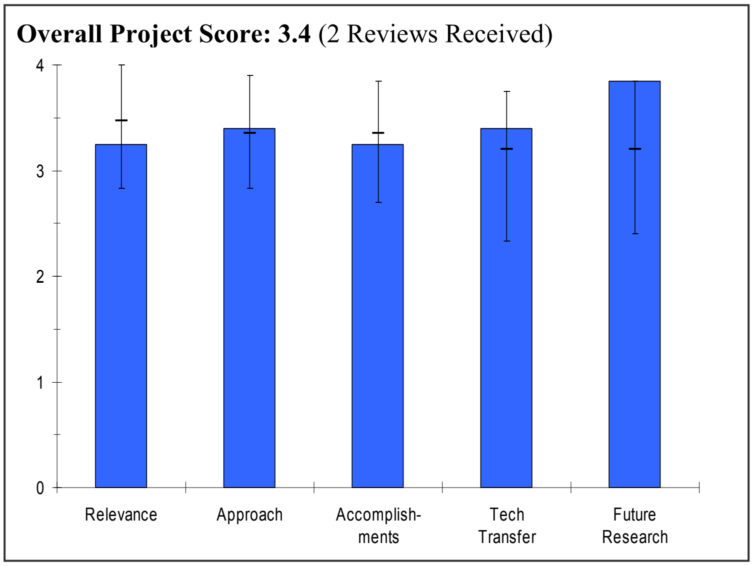
Specific recommendations and additions or deletions to the work scope

- Clarify or amend items under weaknesses.
- Include academic input in the project/model. Possibly consult with T. Molter of University of Connecticut or Jean St. Pierre of University of South Carolina.
- Include electrical costs in the project/model.

Project # AN-05: Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System
George Tolley; RCF, Inc.

Brief Summary of Project

The purpose of this project is to deal with the chicken or egg problem between the supply of hydrogen fuel and the purchase of hydrogen vehicles, using agent-based modeling. The overall aim is to answer the questions: will the private sector invest in hydrogen infrastructure and what, if any, policy assistance is needed? The agent-based model explains the investment in a hydrogen infrastructure and purchase of hydrogen vehicles. Investors supply the infrastructure that makes hydrogen fuel available. The fuel demand is by drivers who purchase hydrogen vehicles.



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Very important that we do everything possible to understand barriers, risks, and tradeoffs to all aspects of commercialization.
- This project scope looses much of its value if stationary fuel cell systems can be used to co-produce hydrogen for refueling stations. This approach attenuates the chicken-in-egg problem.
- Model assumes interest rate of 5 to 15 %, which is too low for new technology and will underestimate costs.
- Economies of scale in mass-production of distributed hydrogen generators could out-pace centralized generation, particularly under the hydrogen co-production approach using stationary FCSs. Model omits this possible evolution.
- A constant price over time was exhibited for distributed hydrogen; model omits economies of scale in mass production for these units. This is an error.
- The exhibited policy conclusions by the model should be explained.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- Approach is decent with the acknowledgement of barriers at hand.
- Agent based model approach is very informative.
- There are a few fundamental weaknesses of the "MBA" approach or NPV analysis. One is the inability to accurately predict future positive and negative cash flows. A more crucial weakness of the NPV approach relevant to this group of people is errors in accurately estimating the genuine risk of a new technology project. The methodology chooses a "similar" project of perceived similar risk. However, if a project is genuinely technically innovative, making analogies to previous new technology projects may not be appropriate. The discount rate for a new wind energy project may not be the appropriate discount rate as for a new tidal energy project.
- The model does not appear to necessary change the discount rate as the investor learns. This should be examined because as the investor starts out, the discount rate should be higher and as he/she learns more, it should decrease.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- The rate of progress for this project is low compared to the amount of money spent.
- Detailed business model is very impressive.
- FY08 accomplishments were not delineated clearly in the talk compared with FY07 accomplishments.
- The stated goal of this project is to "address the chicken-in-egg" problem for refueling stations. However, the speaker stated that he was considering the case of all the technical risks etc being worked out and therefore an interest rate of 5 to 15% was reasonable. This approach is financially incorrect. It fails to address the technology development-financial risk interface which is precisely the primary bottleneck in deploying these fleets and stations. One of the biggest bottlenecks to deploying stations and vehicles is their technical risk. This risk results in higher interest rate, which was ignored. In this way, the project fails to address the most important barrier to fleet deployment.
- Slide 16 shows valuable information about adopter traits vs. penetration, but was also shown at AMR 07. Has any new work been accomplished regarding this relationship?

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.4** for technology transfer and collaboration.

- For this kind of work, they need more partners.
- Industry cooperators provide a good connection to reality.
- Use of production and delivery models is good.
- Collaborations with these organizations will help make the project more relevant, used, and accepted: Argonne National Laboratory, BP, Ford Motor Co., Protium Energy Technologies and industry advisors.
- Collaborations should include data input from hydrogen electrolyzer manufacturers and a grid electricity-to-hydrogen via electrolysis scenario.
- Modeling work should include scenarios in which hydrogen is co-production in stationary fuel cell systems; this scenario is currently lacking as well as collaborations with industry to accurately describe this option.
- A common definition among collaborators for "chicken" and "egg" should be agreed upon.
- Is it realistic to have 76% penetration to passenger vehicles and zero for the rest of the broader vehicle fleet as exhibited?

Question 5: Approach to and relevance of proposed future research

This project was rated **3.9** for proposed future work.

- Carrying this through to include federal policy impacts is very important.
- Recommend that future work include coordination with David Greene.
- Fleet adoption should be considered in addition to household adoption.
- Analysis does not take into account financial benefits of "learning" how to design and deploy technology better as exhibited by the levelized cost of the stations being the same regardless of the year they are built.
- Analysis has not taken into account technology progress in the past few years. The model's assumptions about the performance and cost of the steam methane reformers (SMRs) are out-dated.
- Assumption that centralized production will be cheaper than distributed production may not be correct.

Strengths and weaknesses

Strengths

- This development could prove intuitive or something completely unexpected.
- Development and inclusion of upper management module is a strong point.
- Refueling stations have been built, but their utilizations (such as Praxair's station) are only 1%, due to a lack of vehicles. The project attempts to address this kind of impediment to fleet deployment, though not with great

accuracy given its assumptions of an overly low discount rate (5-15%) and no co-production of hydrogen from stationary fuel cell systems (a scenario that would tend to mitigate the concern of a lack of available refueling stations).

- The measurement units are not shown for Vehicle Adoption Rate.

Weaknesses

- Given the partners involved, the outcome is probably intuitive.
- The same usefulness of results could be achieved with a simpler model.
- Speaker recommends tax credit on the purchase of hydrogen vehicle but should indicate the amount of the tax credit. The presenter only plots the differential between the current vehicle price and the hydrogen fuel cell vehicle price.
- If the speaker is exploring the non-optimum, he should focus on the perceived risk / interest rate assumed and errors in estimating future revenues and costs.
- Results were not well-labeled or explained, such as showing the cost of station but not their size.

Specific recommendations and additions or deletions to the work scope

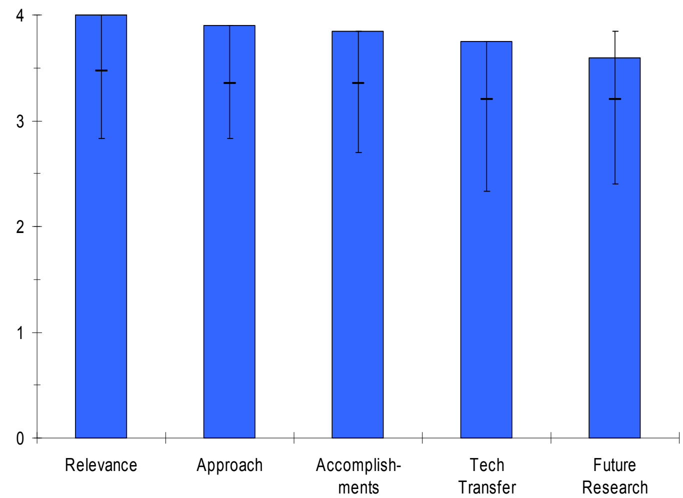
- Program could use more diversity in partners, maybe international ones.
- Broader coordination with other models - others will benefit from this project.
- Consider expanding this approach to cover other aspects, such as vehicle commercialization.
- The amount of funding for this project, $3 million, is much too high for the amount of work being contracted for and the quality of results presented. This project is a modeling project, and therefore is not as capital intensive as design and build projects. The project's budget should be cut to be more in-line with similar modeling projects.
- Please show more concrete results such as that shown in slide 10.
- Please reduce funding for this project significantly. The project's faulty input assumptions severely limit the utility of the results.

Project # AN-06: Hydrogen Technology Analysis: H2A Production Model Update
Darlene Steward; NREL

Brief Summary of Project

The H2A hydrogen production cash flow analysis tool was developed to 1) provide a consistent approach for tabulating the primary cost elements for hydrogen production over the lifetime of the facility; 2) provide a template for reporting analysis assumptions; and 3) calculate the annualized cost of hydrogen produced as a benchmark for comparison of technologies and measurement of progress. The objective for updating the H2A model is to focus the model updates to address the Hydrogen Program barriers.

Overall Project Score: 3.9 (2 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **4.0** for its relevance to DOE objectives.

- It is absolutely necessary that there be one model that is used to calculate hydrogen cost.
- The H2A model, now with the new updates, is optimized and more accurately models cash flow for various pathways.
- The H2A model is important for standardizing the calculation of hydrogen production costs using a variety of feedstocks, technologies, and pathways.

Question 2: Approach to performing the research and development

This project was rated **3.9** on its approach.

- The presentation format of barrier strategy is excellent and shows thorough planning.
- The PI clearly addressed each key barrier and the corresponding strategy/update to the H2A model to address each barrier.
- The strategies/approaches to updating to version 2 are well defined.
- The new version appears to be much more user friendly.
- Making model more user-friendly is necessary for Macro-System Model (MSM) model integration and greater usage, but the speaker has not conveyed any intellectually stimulating results from this model update.
- It is not clear why the per unit costs are increasing between H2A version 1 and version 2. The benefits of this update are not conveyed.
- Model seems to be mixing current costs for some items with future expected costs for others. These two very different approaches to cost-estimates should be clearly separated in the model.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.9** based on accomplishments.

- Very impressive list of additions/enhancements made during the past year.
- All critical barriers have been addressed by the PI.
- This presentation did not show enough results, which makes the technical accomplishments to-date less impressive.
- Importance of model changes not demonstrated.

- Installing plant scaling is not a major accomplishment.
- "Use Excel variable naming to identify and locate critical input and output" is a limited achievement.
- "Provide detailed written documentation of methods and assumptions" should have done years ago.
- The information provided on "130% of daily production capacity" should be explained better.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.8** for technology transfer and collaboration.

- Very good, qualified team developing the model.
- Model availability and support is excellent.
- As evidenced by various studies/models that have referenced/used H2A model, the technology transfer & collaborations have been excellent.
- Acceptable partnering with other modelers, labs, and companies was incorporated in the model development.
- All acronyms should be defined in the presentation such as "CCS", "AEO", and "TOC".

Question 5: Approach to and relevance of proposed future research

This project was rated **3.6** for proposed future work.

- Plans for the coming year do not look as impressive as the accomplishments from the past year.
- There are more pathways to model and enhancements to be made.
- As more and more users are trying out the new version, feedback for improving the model needs to be monitored and factored in future maintenance and updating of the model.
- More validation of independent users based on real life data is needed for further refinement of the model.
- More detailed information should be provided about the planned "future work".

Strengths and weaknesses

Strengths
- H2A is becoming the hydrogen cost standard.
- The new version 2 now builds in much needed updates to address critical barriers.
- Costs of carbon capture vs. plant size were plotted but more example results should be shown.
- Necessary model improvements appear to have been made, though not demonstrated to reviewers.

Weaknesses
- Development effort seems to be tapering off.
- Perhaps more end-user education and feedback are needed.
- Importance of model changes not demonstrated.
- Plant scaling tool kit is not an impressive accomplishment.
- Lack of recent model validation is a weakness.

Specific recommendations and additions or deletions to the work scope

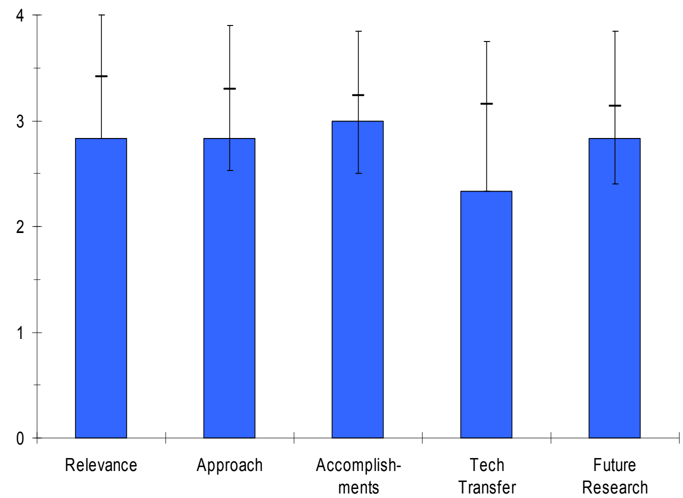
- Become more aggressive in developing production pathways and enhancements to the existing pathways.
- A review session with modelers would be helpful to go over their models one-on-one.
- This presentation did not present any new research results. It showed that an inconsistent approach to modeling costs was being fused into the model (specifically, combining future costs for some items (carbon sequestration) with current costs for other items). It did not demonstrated enhanced model capabilities. As a result, funding for this research should be cut. This project is under-performing.

Project # AN-07: Water Resource Analysis for Hydrogen Infrastructure
Rich White; LLNL

Brief Summary of Project

The objectives of this project are to 1) characterize the water requirements for hydrogen production; 2) develop the framework for assessing the impact of water in hydrogen production; 3) conduct comparative analysis with water use for other fuel options; and 4) evaluate regional condition that may impact the adoption hydrogen production for a particular region. Water requirements will be assessed inside the hydrogen plant (water intensity, water quality, impact of water on hydrogen costs) and external requirements in support of hydrogen production (embedded water of input resources, source reliability, regional water influences).

Overall Project Score: 2.9 (3 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **2.8** for its relevance to DOE objectives.

- This analysis is not only important for hydrogen production, but needs to be extended (with funding from the Renewable Energy Biomass Program) to cover all potential renewable fuels.
- Though water is an important consideration in the production of hydrogen, it is not a critical factor in the Hydrogen Initiative R&D program.

Question 2: Approach to performing the research and development

This project was rated **2.8** on its approach.

- Sound approach beginning with literature search and ending in integration with the Macro-System Model (MSM) and benchmarking.
- Project is poorly designed. PI has chosen preliminary cases that may or may not be relevant, and it was not clear why or what were the underlying assumptions which justify the PIs choice of processes or process subsets. For example, biofuel from corn ethanol is not a relevant benchmark. There are numerous hydrogen production options that may indeed be most important in the future but these are not included in the project.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Project is less than a year old; however, excellent flow paths have been developed for several fuel pathways.
- The PIs early result that hydrogen water intensity can be kept low with new technology at small cost relative to the cost of hydrogen is a sufficient conclusion to the program and therefore further resolution in more detail is not that important. The comparison of hydrogen production to gasoline or corn ethanol production is like comparing apples and oranges and has no bearing on the assessment of water use between different hydrogen production options.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.3** for technology transfer and collaboration.

- Collaboration with other modelers is great.
- PI states collaboration with several labs, but there is no indication that there is any collaboration with industrial producers of hydrogen for establishing base case and benchmark realism.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.8** for proposed future work.

- Please include comparison with other alternatives with the same assumptions.
- The project is working from a very good plan.
- The future plan was presented but it is difficult to see how the plan will extend or build upon the state of knowledge using the current results to generate knowledge that is meaningful beyond what has already been assessed.

Strengths and weaknesses

Strengths
- Clearly shows the water requirement for the hydrogen production.
- Strength is in the team performing the research.

Weaknesses
- Need to be thinking about involving industry as an advisory group.
- No collaboration with industry, limited approach, uncertainty of assumptions, and unidentified project targets weaken this project considerably.

Specific recommendations and additions or deletions to the work scope

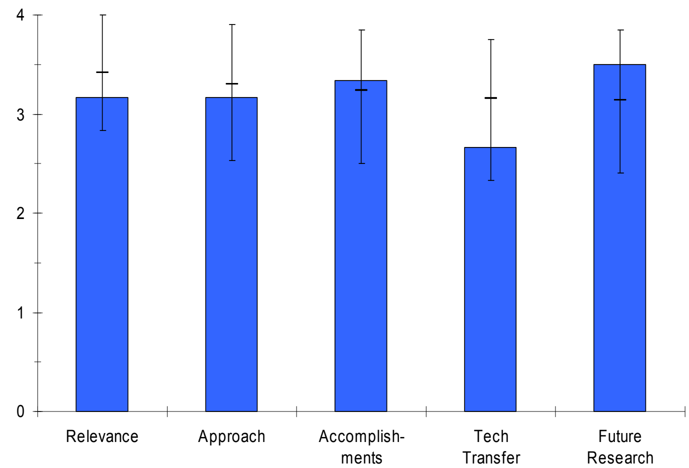
- Share the same assumptions with other energy alternatives such as biofuel.
- Indicate the absolute amount of water compared with other water consumption in the area
- This analysis needs to include other fuel pathways, such as coal-to-hydrogen.
- It is recommended that the current results be documented in a report and the project brought to a conclusion.

Project # AN-08: HyDRA: Hydrogen Demand and Resource Analysis Tool
Witt Sparks; NREL

Brief Summary of Project

The objective of this project is to develop a web-based GIS tool to allow analysts, decision makers, and general users to view, download, and analysis hydrogen demand, resource, and infrastructure data spatially and dynamically. For the fiscal year 2007/2008, 48 datasets viewable as graphical maps were created and integrated. Data manipulation and analysis tools, as well as application security, were implemented.

Overall Project Score: 3.2 (3 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

- The project aligns with Hydrogen Vision and the development of system analysis tools to analyze various hydrogen energy technology scenarios for providing technical inputs for R&D, deployment, market, and policy decisions supporting the overall Hydrogen Initiative.
- Understanding spatial resources, infrastructure, and potential demand data is important for correctly modeling the possible dynamics of transition to a hydrogen fueling infrastructure for particular regions; hence this project is important to the overall Systems Analysis effort.
- A graphical and simplistic view at the potential hydrogen demand and available feedstocks/resources to produce the hydrogen is in line of the overall objectives.
- Not entirely clear on the effectiveness/usefulness of the model.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- A useful feasibility analysis, user-friendly tool has been developed and further improvements in look, applicability, and effectiveness will be continued.
- This tool will help in identifying R&D needs for overcoming some known barriers--such as reducing hydrogen production costs—in addition to furthering understanding of issues and opportunities in large-scale deployment of hydrogen fuel.
- Project uses web server and GIS technology to make available resource, infrastructure, and potential hydrogen demand data in a visual manner, superimposed on maps of the United States. Approach seems reasonable and straightforward.
- Very good in pulling in data from various sources to predict demand and resource availability
- It is not clear that the factors/data considered will have a great influence on hydrogen demand in the future—the demand will be influenced by cost and reliability advantages of fuel cell vehicles over conventional technologies.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Significant progress consistent with baseline objectives has been made within time and cost parameters.

- Project appears to have accomplished its objectives in a timely manner and has not run into any technical hurdles. Security issues prevent dissemination of some data on infrastructure to non-federal employees, which is outside the project's control.
- The PI showed great progress in compiling a great amount of data and the integration of the model with the other models.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.7** for technology transfer and collaboration.

- The project has some coordination with Mountain Top, LLC for its programming expertise.
- Outside consultant brought in to help w/ software development, which is a cost-effective approach. Collaboration w/ other projects as appropriate is planned (e.g. Macro System Model).
- Model needs to be validated by third party and industry.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.5** for proposed future work.

- Future work is well planned and will enhance the application of the tool.
- The list of planned work is impressive.
- Proposed future data sets to be added seem appropriate and helpful to overall goals of systems analysis program.
- Might need to consider adding a layer that contains information on hybrid vehicle purchases/uses around the countries. This will show public's willingness to embrace greener, more efficient technologies such as hybrids. These areas are likely to adopt fuel cell vehicles quicker, leading to the need for hydrogen demand/new infrastructure installation.

Strengths and weaknesses

Strengths
- A useful, interactive tool to understand and analyze a variety of scenarios relevant to production, transport, and uses of hydrogen fuel is needed by technical, management, and policy people. This work supports that need.
- Project is well-structured and focused. Project has clear and rigorous methodology.

Weaknesses
- No weaknesses were noted.

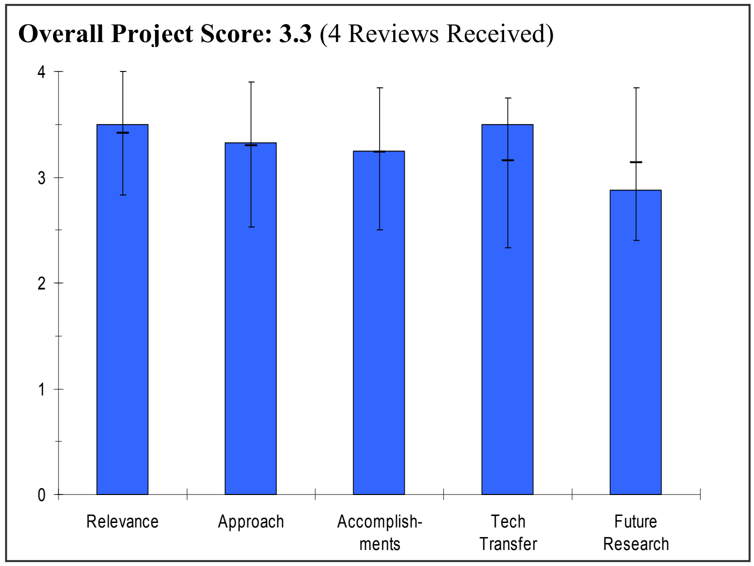
Specific recommendations and additions or deletions to the work scope

- Build advanced capability by interfacing with other relevant models available in the hydrogen portfolio.
- Recommend considering adding data on local rates of taxation, labor, cost of construction, skills relevant to building & operating H2 stations, etc. as this could be helpful inputs to other models (e.g. H2A, or H2A through MSM) to be able to derive possible costs of construction for hydrogen fueling infrastructure.

Project # AN-09: Lessons Learned for Fueling Infrastructure

Marc Melaina; NREL

Brief Summary of Project



The objective of this project is to collect and articulate lessons learned from past experiences that can improve future decisions related to hydrogen fueling infrastructure development. Experiences to draw upon include 1) ethanol, natural gas and other alternative fuels for vehicles; 2) success with compressed natural gas vehicles in Argentina; 3) early development of the natural gas pipeline infrastructure; and 4) recent expansions of gasoline station networks in key urban areas. The approach consists of four tasks: 1) conduct a facilitate one day expert workshop; 2) collect empirical data on the success with natural gas vehicles in Argentina; 3) analogies to early natural gas infrastructure development; and 4) spatial evolution of urban gasoline stations.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Very relevant to DOE goals—provides input on progress made and offers new options.
- Very good input on positive results and things that need correction.
- This program should provide insights into infrastructure deployment and expansion.
- Understanding lessons from previous successful and unsuccessful efforts to introduce new alternative fuels is important for developing a successful strategy to introduce hydrogen as a transportation fuel.
- Gaining understanding of other successful and accelerated introductions of fuel infrastructure can be very beneficial.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Excellent approach in logically organized fashion.
- Includes alternative fueled vehicle H_2 station demo and innovation experience from expert organizations.
- Report summary is sent to participants for comments. This is very productive approach.
- Historical perspective of natural gas & gasoline vehicles is employed in a very useful way.
- It is unclear why natural gas vehicle data was collected from Argentina when the United States has years and years of natural gas vehicle deployments and end users. Consider approaching GM, Ford, and Chrysler along with the other fleet users for additional information about this database?
- Approach involved consulting relevant experts from industry, government, academia, and foreign experts. Approach seems reasonable and cost effective.
- Selecting compressed natural gas in Argentina as a study case is a very good place to start.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Break-out session input is very well organized, analyzed and presented.
- Hydrogen value proposition (multi-purpose solution) is an important input from the analysis.
- Argentina's natural gas vehicle success story is a great example for United States.
- Study uncovered some previously unsuspected technical, economic, and administrative hurdles to be overcome, which is highly significant. For example, the study determined that expertise to design and build H2 fueling stations is a significant bottleneck. Also, siting and permitting processes are likely to take considerable time. Right now, perhaps insufficient effort is being put into addressing these problems by the DOE program.
- Starting in January and completing a workshop already is significant; although, scoring should not apply to this project.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.5** for technology transfer and collaboration.

- Workshop idea is a great tool and effectively utilized.
- Attaching with NHA conference was also a good way to get experience participants.
- Decent levels of participants but needs to have more participants from the United States.
- Experts from industry, government, and academia were consulted. Results will be widely disseminated via technical report.
- Focus on California is probably not representative of what could or will happen in the rest of the country.
- Recognize that it is early in the project; however, collaborations will need to expand for this project to thoroughly analyze lessons learned.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.9** for proposed future work.

- Alternate vehicles should include hybrids, with hybrid FCVs being most important and especially as plug-in hybrids look very promising.
- Lots of possible future directions suggested, project needs to downselect. This reviewer suggests looking more in depth at factors contributing to successful introductions of compressed natural gas in Argentina, as well as ethanol in Brazil, compared with less successful efforts to introduce compressed natural gas in other countries.

Strengths and weaknesses

Strengths
- The National Renewable Energy Laboratory has very good experience in collecting data and analyzing lessons learned.
- Collected good international data but a direct correlation to the behavior in the USA will be a big mistake. Different societies integrate technologies differently.
- Project is well-structured and focused. Project has clear and rigorous methodology.

Weaknesses
- Statistical data on success as well as issues are not presented. This may be very useful.
- The NGV graph regarding vehicles per station just does not look right. The USA has over 1000 Natural Gas Vehicle (NGV) fueling stations and quite a few NGV vehicles; however, this graph does not show it at all.
- Project has too many directions; it should develop a more focused scope. Suggest a downselect to concentrate on identifying factors behind successful and unsuccessful foreign introductions of CNG and ethanol.
- Project is so limited in time that it is going to be difficult to achieve the kind of results that will significantly impact future federal policy.

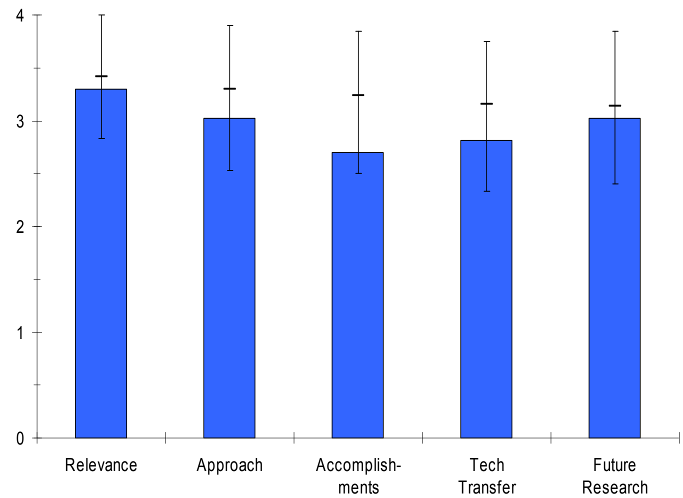
Specific recommendations and additions or deletions to the work scope

- Include H-CNG vehicles also for emission advantages.
- Include benefits of fleet vehicles to provide effective service at low cost.
- Lots of possible future directions suggested, project needs to downselect. This reviewer suggests looking more in depth at factors contributing to successful introductions of CNG in Argentina, as well as ethanol in Brazil, compared w/ less successful efforts to introduce CNG in other countries (e.g. Italy). Project should perhaps also pay special attention to possible cultural influences on success or failure of alt. fuel introduction efforts. Recommend less emphasis on studying infrastructure development in early 20th century, as this may have less relevance for today's situation (namely, the early automobile and gasoline were competing against less useful established modes of transportation, e.g. horse and buggy).
- This project will scratch the surface, but will not provide adequate information for DOE to recommend policy that will lead to sustainable hydrogen refueling.
- If DOE is really looking for information to guide hydrogen refueling introduction and growth, many additional successful and failed scenarios should be evaluated. Lessons learned must then be screened for applicability to the situation in the US.

Project # AN-10: Hydrogen and Fuel Cell Analysis: Lessons Learned from Stationary Power Generation
Scott Grasman; U Missouri-Rolla

Brief Summary of Project

Overall Project Score: 2.9 (5 Reviews Received)



The objective of this project is to collect and articulate lessons learned from past experiences that can improve future decisions related to hydrogen fueling infrastructure development. Experiences to draw upon include 1) ethanol, natural gas and other alternative fuels for vehicles; 2) success with compressed natural gas vehicles in Argentina; 3) early development of the natural gas pipeline infrastructure; and 4) recent expansions of gasoline station networks in key urban areas. The approach consists of four tasks: 1) conduct a facilitate one day expert workshop; 2) collect empirical data on the success with natural gas vehicles in Argentina; 3) analogies to early natural gas infrastructure development; and 4) spatial evolution of urban gasoline stations.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Will provide useful information based on operating experience obtained from first time users of fuel cell technology.
- The project provides a good understanding about the synergy of stationary and transportation FC markets and linking them may keep both markets viable to support early entrant manufacturers solvent.
- Many different hydrogen and fuel cell systems have been demonstrated and deployed world-wide.
- It is appropriate at this time to take stock of how well they have worked out in meeting their test and demonstration goals, and to identify what significant issues have arisen.
- Understanding how stationary and other early market fuel cells are performing in the marketplace is relevant to the objectives of the DOE Hydrogen Program, specifically to efforts to advance fuel cell technology.
- It is very important that we learn from all relevant experiences relating to hydrogen as an energy carrier.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- A logical, structured approach with well-defined tasks including pathway analysis and ending with strategy recommendations.
- The project has a fair to good approach to performing the research and development. Information on market research or industry collaboration should be provided.
- The listed approach is systematic. It should lead to meeting the objectives of the project.
- No criteria were given or discussed as to how they would rate the success, or otherwise, of past or current fuel cell installations.
- It was not clear how the performance and other data would be obtained for the 2500 installations or demonstration projects.
- Project is collecting data on various fuel cell projects, and on what has worked to make them successful or not (Tasks 1-3). This seems like a reasonable approach. Examine the value of pathway analysis. The differentiation between Task 4 and Task 5 should be better defined.

- Well thought out plan that is thoroughly investigating stationary experiences.
- Changing from a workshop in St. Louis to a symposium at National Hydrogen Association in March is a great idea, as long as they retain the interactive breakout sessions and the sessions are well planned.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.7** based on accomplishments.

- Fairly new project. Good progress has been made to date.
- The technical accomplishments and progress toward project goals are fair. No evidence of progress was exhibited, just a check list stating level of completion.
- They have completed Task 1 and they are half-way through Tasks 2 and 4.
- No specific results were presented. It would have been useful if some detail of grouping of the 2500 projects was given, e.g., types of fuel cells, power ratings, combine heat and power (CHP) or not, co-generation of hydrogen or not, geographical and temporal distribution, current or past, or other deployment parameters.
- Progress to date has been unexceptional. Important project milestones are yet in the future.
- Very reasonable progress has been accomplished for less than a year of research.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.8** for technology transfer and collaboration.

- The project as some informed interactions but it wasn't clear what role these partners will play and what their specific contributions will be.
- The project's technology transfer/collaboration is fair but limited collaborations or sources were noted.
- The project should consider potential fuel cell demonstration sponsors other than DOE.
- An outside consultant is planned to assist with software development, which is a cost-effective approach. Collaboration with other projects as appropriate is planned (e.g. Macro System Model).
- Utilizing National Hydrogen Association as a forum to vet results is outstanding.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.0** for proposed future work.

- The future project plan is adequate.
- Completing the data collection is good. Unsure of the need or reason to have a workshop.
- They propose to complete the tasks given in the approach section.
- No criteria are given for Task 3, Analysis and Lessons Learned, and Task 4, Pathway Analysis.
- Proposed future data sets to be added seem appropriate and helpful to overall goals of systems analysis program.
- Data collection followed by a workshop to consolidate and vet findings is great. Need to assure adequate planning for meeting at National Hydrogen Association to assure maximum benefit from a one day session with industry experts.

Strengths and weaknesses

Strengths
- The project has a good approach.
- This project may help DOE support both stationary and transportation early adoption.
- The project has a systematic approach.
- The project is investigating 2500 applications.

Weaknesses

- Presentation did not show any data collected to date. It would have helped to see where data collection is at. A few examples would have helped.
- There is a lack of apparent industry collaboration.
- The project needs to develop criteria for analyzing and rating success of past and current demonstrations.
- The project needs to identify how operating and other data will be obtained.
- The project needs to identify how they will sort through 2500 projects and 1000 fuel cell developers.
- The approach was not clearly explained, particularly Tasks 3 & 4.

Specific recommendations and additions or deletions to the work scope

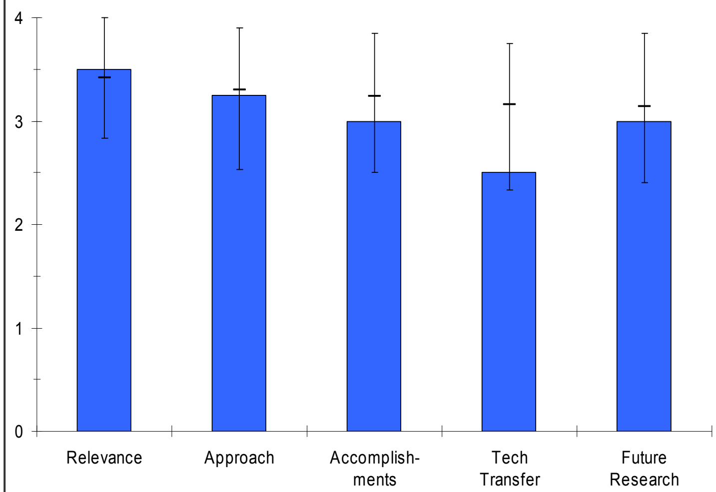
- Demonstration of industry collaboration to add fidelity to the analysis.
- The approach described in the summary at the end is not consistent with the 5-task approach discussed at the beginning of the presentation. Need to clarify what it is that they will do.
- Recommend looking at what alternatives to use of fuel cells would have been for each project evaluated, and factors that led to selection of fuel cells over the alternative. Recommend looking at whether fuel cell advantages/disadvantages for other markets are relevant to use of fuel cells for transportation.
- The project should include compression planning in meeting at National Hydrogen Association.

Project # AN-11: Hydrogen Quality Issues for Fuel Cell Vehicles
Romesh Kumar; ANL

Brief Summary of Project

The objectives of this project are to 1) assess how fuel quality influences the life-cycle costs and performance of the overall "hydrogen system" – production, purification, use in fuel cell vehicles, and analysis and quality verification; 2) identify information gaps and the research and development needed to fill those gaps; and 3) develop a roadmap that determines the significant cost elements, identifies challenges to reducing those costs and makes recommendations on how to address those challenges. Models will be developed to evaluate the quantitative effects of fuel quality on the costs of hydrogen system components.

Overall Project Score: 3.1 (2 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Will provide useful input to FC developers regarding hydrogen quality and associated costs.
- This work is critical in recognizing the cost impact of purity levels and contributing input into set appropriate purity standard.
- Analysis of hydrogen quality/purity for fuel cell vehicles is extremely important
- Please explain the reasoning behind focusing on four contaminants primarily (slide 4) (N_2, CO, CH_4, CO_2). These molecules found in hydrogen gas, air, and water, are impurities that can affect fuel cell performance.
- Understanding the trade-off between costs and contaminant levels is important (slide 4).
- Work is differentiated from other work by ASME and others, because of focus on life cycle costs, not just delivered cost of hydrogen.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- Well-structured approach including cost analysis and trade-offs affecting life cycle cost. Approach bared primarily on modeling rather than actual data collection.
- Looking at SMR + PSA product impurities and their effects on fuel cell performance & life cycle cost is a good approach. However, PI needs to consider other hydrogen production pathways and how fuel standard will have effects on these pathways' life cycle costs.
- The project might also need to look at tradeoffs of high temperature shift (HTS) + pressure swing absorption (PSA) vs. high temperature shift (HTS) + low temperature shift (LTS) + PSA vs. no water gas shift (WGS) + PSA vs. membrane vs. PSA, etc.
- Work should focus not just on pressure swing absorption (PSA) but also other technologies, such as EHS (electrochemical hydrogen separation), palladium membranes, preferential oxidation (PROX), methanation, etc.
- Integrating a portion of this work into the H2A model could be quite valuable.
- Were the models based on chemical engineering models or on experimental results? Are these ASPEN chemical engineering run results or a custom model? How does the custom model work?

- Sulfur is an odorant added to natural gas. However, the study considered a natural gas composition without any sulfur. This assumption is very favorable to fuel cells. A better explanation is needed to understand the reasoning for adding H_2S to the water gas shift (WGS) outlet. Project needs to comply with conservation of mass principle.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.0** based on accomplishments.

- Good progress has been made to date in modeling analysis and presentation of results.
- Good progress has been made to date. Would like to see some work/discussions/collaborations with groups/agencies working on hydrogen standards (International Organization for Standardization—ISO, California Fuel Cell Partnership—CaFCP, etc.).
- The project is producing excellent results. Work should receive a DOE award. Argonne National Laboratory's (ANL's) work adds great value to understanding impurity changes on the macro-system effects (hydrogen costs, mileage, etc.), and stack efficiency.
- Please show more results for additional impurities, not just CO.
- Database of critically assessed relevant published literature is very valuable.
- Integrating this information into existing models is extremely valuable.
- "Developed methodology to evaluate cost effects" using H2A is excellent accomplishment.
- The project demonstrates fascinating feedback loops between engineering system design and cost.
- More discussion of the drivers/reasons underlying results should be provided.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.5** for technology transfer and collaboration.

- Some work/discussions/collaborations with groups/agencies working on hydrogen standards (ISO, CaFCP, etc.) is needed as these type of work are valuable in helping these working groups setting realistic fuel standards.
- OEMs, Energy Companies, National Laboratories are good partners. Convened an excellent working group with different partners. Outreach meetings are excellent.
- Getting input from fuel cell developers, gas suppliers, etc. increases the relevance and utility of this study.
- Continued collaboration with industry is critical for project utility.
- Define the acronyms such as "TPSA" to increase audience understanding. Define recycle ratio, variables in table (delta_V (change in voltage) and delta_n (change in efficiency)) for the benefit of all audience members.
- This excellent work should be published.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.0** for proposed future work.

- Good plan for future work based on extension of results to date.
- The project needs to look at other hydrogen production pathways.
- The project needs more collaboration with agencies in charge of setting hydrogen fuel standards.
- The project has nice ideas for future work. The project should consider "renewable sources" for hydrogen fuel generation such as anaerobic digester gas and landfill gas. These gases will have more impurities, be more difficult to clean-up, and will require more purification equipment. The project should perform a benchmark analysis on the "marginal cost" of going to a renewable fuel, in terms of the additional cost of the hydrogen purification equipment.

Strengths and weaknesses

Strengths
- Interactive workshops with industry and international participants are quite valuable for the community.

- Integrating this work into the H2A model is valuable.
- The results for different inlet gas to the PSA cases, costs as a function of natural gas price, steam methane reforming (SMR) efficiency, and costs as a function of hydrogen purity level are extremely useful and demonstrate project progress.
- This presentation summarizes key results which is excellent. DOE should use this presentation's format emphasizing results as a model for other AMR presentations.

Weaknesses

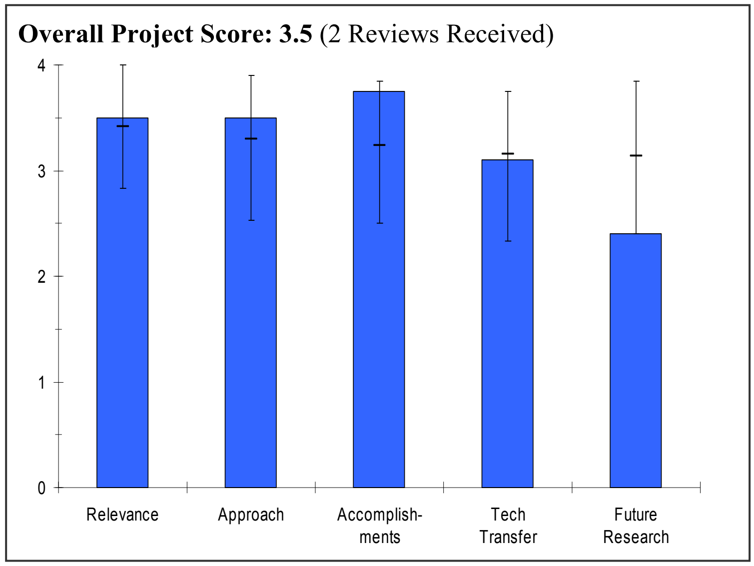
- To improve this work, it should focus not just on pressure swing absorption (PSA) but also other technologies, including, but not limited to EHS (electrochemical hydrogen separation), preferential oxidation (PROX), methanation, etc.
- The reasons for focusing on only four contaminants (N_2, CO, CH_4, and CO_2) should be more clearly justified. Other contaminants such as sulfur compounds can be equally or more of a problem for fuel cells.
- The focus on natural gas as a fuel should also be reconsidered. Expanding the feedstock fuels evaluated to biofuels (ethanol) and biogas, LPG could be even more helpful to some of the cutting-edge system designs taking place currently.
- A more detailed discussion of model inputs and function, and results for a wider array of cases should be provided.

Specific recommendations and additions or deletions to the work scope

- Some comparison with actual fuel cell operation conditions would be useful. Data would be available from Dr. Wipke of the National Renewable Energy Laboratory (NREL).
- This research should examine more contaminants in addition to N_2, CO, CH_4, and CO_2.
- Convey more information about the assumptions, physics, and economics behind the model.
- Evaluate other hydrogen purification technologies (palladium membranes, electrochemical hydrogen separation) in addition to pressure swing absorption (PSA).
- Evaluate greater variations in natural gas composition than explored to date. Natural gas composition can vary significantly depending on the source, and regulations regarding purity levels and odorants.
- Consider "renewable sources" for hydrogen fuel generation such as anaerobic digester gas and landfill gas.

Project # AN-12: Update on Platinum Availability and Assessment of Platinum Leasing Strategies for Fuel Cell Vehicles
Matt Kromer; TIAX

Brief Summary of Project



This project updates a 2003 TIAX study on platinum availability and assesses the benefits of a platinum leasing program to support fuel cell vehicle (FCV) commercialization. The objectives of this project are to 1) assess constraints on platinum availability under high FCV penetration scenarios and 2) identify and quantify the benefits of alternative platinum ownership scenarios. The project hopes to answer the following questions:

- Are worldwide platinum resources sufficient to support high market penetration of FCVs?
- Can the platinum supply infrastructure meet the projected demand?
- Can upstream suppliers offer significant cost savings by internalizing the residual end-of-life value of platinum in an FCV's upfront cost?
- What are the risk factors and transaction costs associated with a leasing program?
- Given likely FCV supply chains, how could such a leasing program be structured and deployed?

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.5** for its relevance to DOE objectives.

- Adequate platinum availability for widespread fuel cell vehicle deployment is a recurring concern that has been voiced by many people.
- This concern has been heightened even more by the recent run-up in Pt prices to greater than $2000 per troy ounce.
- Project is covering two extremely important issues.

Question 2: Approach to performing the research and development

This project was rated **3.5** on its approach.

- The approach is systematic and logical.
- It is important to assess the level of confidence in the many different projections that are used in determining Pt demand over time (Slide 3).
- This project exhibited outstanding, straightforward research.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.8** based on accomplishments.

- The project has presented a fairly comprehensive analysis and salient results of the analyses.
- The results show that platinum (Pt) accounts for roughly half of the fuel cell cost but that the supply should be able to meet the demand for the 50% market sales penetration scenario.
- The financial analysis shows that leasing of Pt (or the entire FCV) may not be a very attractive option for the consumer.
- The project was efficiently completed in less than a year.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.1** for technology transfer and collaboration.

- Platinum industry, the automotive OEMs, other interested parties were included in the project.
- Lots of resources used to complete the study.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.4** for proposed future work.

- The project is complete and no future work was presented.
- Completed project.

Strengths and weaknesses

Strengths
- Logical approach, systematic analyses used in the project.
- The wide range of options was considered.
- Realistic inputs for the analyses were utilized from the Pt industry and OEM interests.

Weaknesses
- None.

Specific recommendations and additions or deletions to the work scope

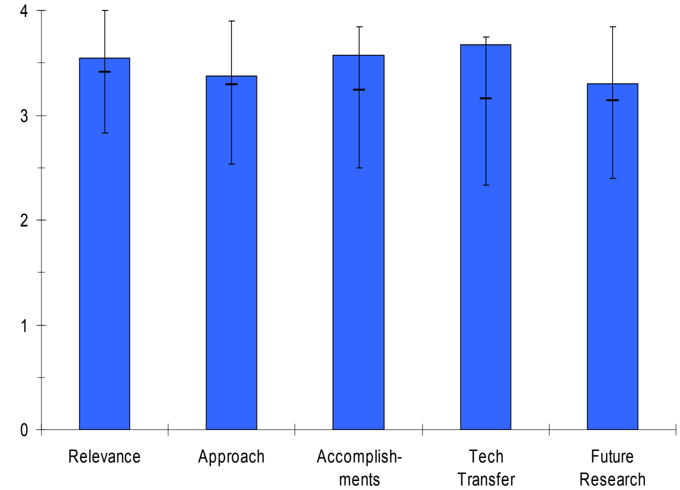
- No future activities are planned.
- The results presented should be useful to DOE and policy makers.
- Periodically, both of these topics should be reevaluated.

Project # AN-13: Evaluation of the Potential Large-Scale Use and Production of Hydrogen in Energy and Transportation Applications

Don Wuebbles; University of Illinois-Urbana-Champaign

Brief Summary of Project

Overall Project Score: 3.5 (4 Reviews Received)



The purpose of this project is to systematically identify and examine possible ecological and environmental effects from the production and use of hydrogen from various energy sources based on the Department of Energy production strategy and use of that hydrogen in transportation and power applications. This project uses state-of-art numerical models of the environment and energy system emissions in combination with relevant new and prior measurements and other analyses to assess the understanding of the potential ecological and environmental impacts from hydrogen market penetration. In the process, the Department of Energy will be provided with a capability for further assessing current understanding and remaining uncertainties for addressing the potential environmental impacts from hydrogen technologies.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.6** for its relevance to DOE objectives.

- Project objectives and intended results are critical for both science and policy decisions to deploying hydrogen energy to stationary and mobile sectors and consistent with DOE hydrogen economy vision and related goals.
- Important work that is necessary to achieve DOE goals.
- This is an interesting project that is seeking to identify a range of potential effects of higher concentrations of hydrogen in the air as hydrogen production and use gets more widespread.
- Understanding how production and use of hydrogen would affect the environment is critically important to the overall DOE Hydrogen Program.

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- The study covers a wide range of relevant topics and answers or will answer many questions on the deployments of hydrogen energy technologies in both the stationary and mobile sectors.
- The study naturally cannot cover all related topics, but it will still contribute to the understanding and options to overcome some key barriers.
- The study covers safety and environmental topics from hydrogen production stage to its end uses; this is appropriate.
- The project approach appears to be sound.
- They are using atmospheric chemistry models to evaluate the potential effects of increased hydrogen concentrations on ground-level ozone and other pollutants on global and regional scales. They are also examining potential effects of hydrogen in the air on structural materials (e.g., embrittlement).
- Project is employing a variety of methods, including climate simulation, calculation of possible effects on materials, and measurements of hydrogen values near existing hydrogen sources. Methodology is extremely comprehensive and rigorous.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.6** based on accomplishments.

- Significant progress towards objectives have been accomplished and presented.
- Progress seems good except that there are a lot of things to finish by the end of FY08.
- They presented early results in many different areas of analysis.
- An interesting result is the much higher uptake of hydrogen by soils than what has been believed to be the case thus far. It should be noted, however, that these results still need to be validated by further testing and analyses.
- Project has already accomplished a number of calculations, showing likely consequences of elevated hydrogen on levels of atmospheric methane, likely composition of troposphere with widespread use of hydrogen, and likely rates of hydrogen uptake by soil and in buildings.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.7** for technology transfer and collaboration.

- National laboratories, University of Illinois, Queen's University, and Stanford University are involved in this important study.
- This team with complementary expertise will shed many insights on the health, safety, and environmental issues of deploying hydrogen to power production and transportation sectors.
- The technology transfer/collaborations seems to be good. The roles of the partners are clear.
- The project should include other universities and national laboratories.
- Projects involve significant collaborations between DOE labs and universities, and leverages relationships with companies involved in hydrogen production and use. Appropriately, cooperation is widespread and lots of data is being exchanged.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.3** for proposed future work.

- Each of the future work items is not only important and relevant, but legitimizes further, continued work to a complete understanding that large-scale production and wide-spread uses of hydrogen is truly safe. Another problem, as serious as ozone layer destruction, must not be created while solving greenhouse gas (GHG) issues.
- Future plans are not well developed particularly in FY09 and beyond.
- They have an ambitious future work plan outlined that includes modeling and experimental components.
- Proposed future research is aggressive and wide ranging, but seems largely doable since most of it involves calculations. Plans are very well focused on project goals.

Strengths and weaknesses

Strengths

- This study will create the awareness needed that there are issues with hydrogen fuel: its emissions during production, reactions with hydroxyl radicals in the atmosphere, its effect on the ozone layer, increased soil acidity, and, overall, the impact of the emissions on climate.
- The project will undertake extensive analyses.
- Project is well-structured and focused. Project has clear and rigorous methodology.

Weaknesses

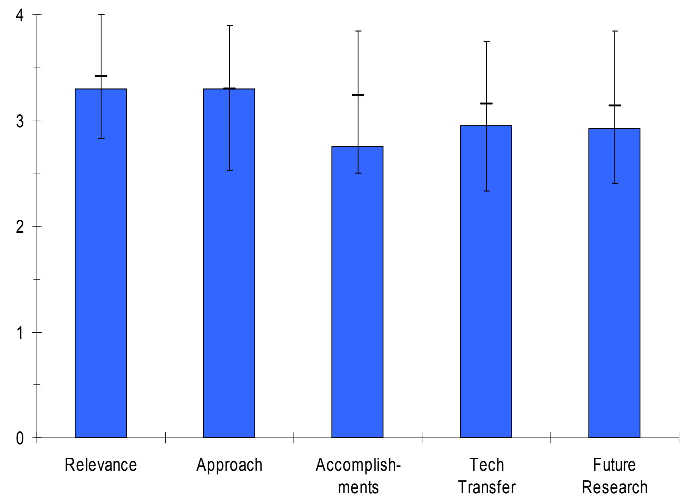
- The project needs to develop plans to validate modeling results.

Specific recommendations and additions or deletions to the work scope

- Conduct a long-term study on the effect of 5 ppm or more measured hydrogen concentration, such as in Mexico City and for the impact on steel and other metallic structures (simulated study is also appropriate).
- Consider different hydrogen production scenarios.

Project # AN-14: Potential Environmental Impacts of Hydrogen-Based Transportation and Power Systems
Thomas Grieb; Tetra Tech

Overall Project Score: 3.0 (4 Reviews Received)



Brief Summary of Project

The objectives of this project are to 1) compare emissions of hydrogen, the six criteria pollutants (CO, SO_x, NO_2, PM, ozone and lead) and greenhouse gases from near and long-term methods of generating hydrogen for vehicles and stationary power systems; and 2) evaluate the effects of emissions on climate, human health, ecosystem and structures. The following will be developed: 1) market penetration scenarios for vehicles; 2) market penetration scenarios for electricity generation; 3) emission-profile databases; and 4) soil uptake model. Changes in hydrogen and other atmospheric gases and aerosols in the troposphere and stratosphere with be predicted. Effects due to the implementation of two market penetration scenarios will be quantified.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Study and understanding of potential environmental impacts of hydrogen-based transportation and power sectors is not only apposite but critical to the success of the engineering developments and ultimate deployment of hydrogen energy technologies.
- One purpose of systems analysis is research and development guidance; this and similar studies presented at the Annual Merit Review will allow technology research and development to overcome identified barriers to large-scale deployment of hydrogen fuel.
- This is critical work for policy goals and objectives.
- This is a useful study to assess the atmospheric effects of increasing hydrogen production and use over the near and long term time frames.
- Project seeks to evaluate impacts on criteria pollutants from widespread use of H_2 for light-duty vehicle infrastructure. This is relevant to understanding the possible benefits in addition to reducing CO_2 emissions that such an infrastructure might have.

Question 2: Approach to performing the research and development

This project was rated **3.3** on its approach.

- The technical approach and the task scopes are highly relevant and if successfully executed, the information will help in overcoming key barriers to deploying hydrogen fuel in the power and transportation sectors. Such system analyses studies are needed now, in parallel with the extensive technology research and development work on-going in production, delivery, and storage areas.
- Project addresses important sources of environmental impacts.
- The project seems to be a bit narrow but appropriate for the funding level.
- After developing emissions profiles as a function of hydrogen-based transportation and power production scenarios, they will conduct studies of the simplified global hydrogen cycle model to project changes in the concentrations of hydrogen and criteria pollutants in the air.

- Project will attempt to calculate production of criteria pollutants and green house gases from a variety of hydrogen production methods (including distributed steam methane reformation) and compare them to current (2005) emissions. Project will use two future scenarios for penetration levels of hydrogen fuel cell vehicles by 2050. The project combines environmental simulations and assessments.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.8** based on accomplishments.

- The project has summarized existing data and developed model scenarios to identify likely emissions and effects on climate, human health, ecosystem, and structures.
- The project, however, assumes that hydrogen is manufactured from renewable sources; this assumption is incorrect, fossil-based technologies will have to be used to produce hydrogen until renewable sources are fully technically developed; the hydrogen leakage intensity is different in the two production scenarios (fossil energy vs. renewable energy).
- Project has only been going 6 months, so modest progress seems satisfactory.
- The project is still at an early stage of execution. A major fraction of the background information has been collected but the analysis activity is just getting underway.
- So far, only scoping of problem has been accomplished.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.0** for technology transfer and collaboration.

- The project partner as of now is Prof. Mark Jacobson, known for modeling efforts, and the other partner is Potomac-Hudson Engineering.
- Stanford University's role is apparent, but the other partner's role is not.
- The collaboration is primarily in the form of using literature data and existing models.
- Project involves collaboration between industry and university. Results will be disseminated through reports and publications.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.9** for proposed future work.

- Follow-up work building on results thus far.
- Both FY 08 and FY 09 task scopes are relevant and needed.
- The plans are for the proposed project are limited.
- They have outlined an ambitious slate of analyses to be conducted in the remainder of the project term.
- Approach and relevance seem good, but could be improved - see comments below. Project should act as a useful check on previous studies/models, e.g. GREET.

Strengths and weaknesses

Strengths
- This study will create the awareness needed that there are issues with hydrogen fuel. Its emissions during production and uses and the resulting impact on health, safety, and environment is a knowledge base that needs to be developed and comprehended.
- The project is utilizing the Stanford University modeling work.
- The project has a good strategy.
- The project has good scope and focus on studying hydrogen and atmospheric pollutants.

Weaknesses
- The project scope may be limited.
- None.

- Project's baseline scenario, assuming pollutant rates commensurate with 2005 technology for vehicles in 2050, is not a believable alternative to widespread use of H_2 vehicles. A more credible scenario is widespread use of plug-in hybrids or advanced electric battery vehicles which would be a future competitor for hydrogen and hydrogen fuel cell vehicles.

Specific recommendations and additions or deletions to the work scope

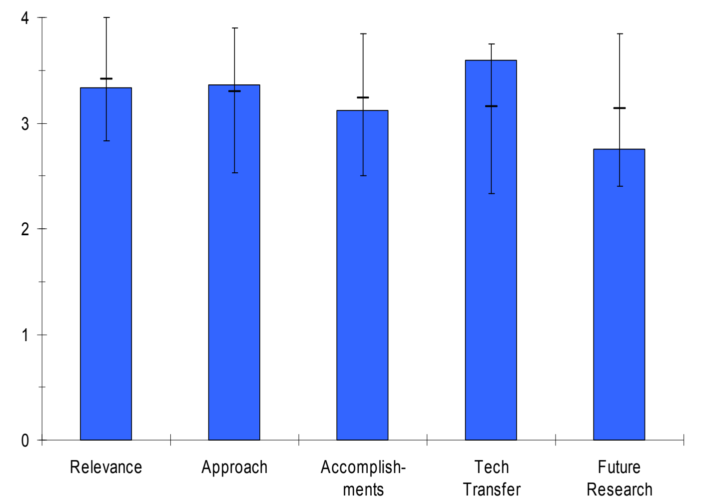
- Study of hydrogen dynamics in the troposphere and stratosphere is very important, but the project scope is limited. Suggest re-scoping for a more detailed study.
- Both fossil and renewable hydrogen production sources should be included in the study.
- Creating another problem as serious as the ozone layer destruction while solving the green house gas problem is not prudent.
- They should identify means to validate modeling results (i.e., how to determine confidence levels for the model outputs).
- Recommend considering changing baseline scenario to widespread use of electric battery vehicles instead of 2005 technology internal combustion engines. Alternative baselines to consider might be compressed natural gas vehicles, methanol internal combustion engine hybrids, or hydrogen internal combustion engine hybrids.

Project # ANP-01: Hydrogen Technology Analysis: H2A Stationary Power Production Model
Michael Penev; NREL

Brief Summary of Project

The objective of this project is to expand the capabilities of the H2A model to evaluate the stationary production of electrical power, heat co-generation and hydrogen co-generation. The H2A mission is to improve the transparency and consistency of cost analysis, improve the understanding of the differences among analyses and seek better validation from industry. The H2A model aims to make analysis consistent, transparent and comparable.

Overall Project Score: 3.2 (5 Reviews Received)



Question 1: Relevance to overall DOE objectives

This project earned a score of **3.3** for its relevance to DOE objectives.

- Results of this work should be valuable for government personnel making decisions on market transformation.
- Expenditures related to stationary applications.
- Results should also be beneficial for private investors in stationary power, heat and hydrogen production.
- This work will reduce the time and cost for analysis of specific hydrogen applications.
- Stationary fuel cell systems are likely to have a significant presence in the marketplace well before the automotive fuel cells do. Therefore, this is a very worthwhile project to undertake.
- Model to calculate value proposition is very important.
- During the transition phase, stranded assets are a concern. The model allows evaluation of different approaches/solutions to this problem.
- Industry input is well-planned.
- Stationary fuel cell systems are not necessarily critical to the Hydrogen Fuel Initiative but this project at least rounds out the capabilities of H2A to include another option that may be of interest to some developers (perhaps help them decide to abandon certain development efforts).

Question 2: Approach to performing the research and development

This project was rated **3.4** on its approach.

- The effort in this project seems to be linked well with prior H2A modeling work, and it also builds on it.
- The approach should provide a modeling tool which is broadly applicable to a variety of conditions.
- At present, their main activity is to develop the strategy for entering the hourly energy demand profiles into an H2A-compatible format. This energy demand will be met by a combination of reformate-based high temperature base load fuel cell system, a load-following direct hydrogen fuel cell system, and renewable electricity.
- The input energy sources are infrastructure fuels, grid power, and renewable electricity (the last one is yet to be added).
- The hydrogen demand is taken as a given at 100 kg/day.
- Extension of H2A model to multiple co-products is very useful.
- Ability to include time of day values of co-products allows the handling of high-peak and low demand scenarios.
- Cash flow analysis should include grid stand-by and demand charges.
- Overall, the approach is good. Detail is necessary in this case to make sure heat and power demands coincide.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.1** based on accomplishments.

- Not Applicable.
- The Principal Investigator stated the project is on track.
- There has been insufficient time to fully develop the model to the point at which specific tangible results could be cited.
- At this early stage of the project, only example input energy sources and demand profiles have been entered into the model.
- Preliminary distributions of the different sources and the demands for electricity (from the reformate fuel cell, the hydrogen fuel cell, and the grid) and heat (from the reformate fuel cell and a burner) have been obtained.
- The model is ready to be exercised for different applications scenarios.
- Program is relatively new.
- This project appears to be making very good progress for just $70,000 of funding spent.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.6** for technology transfer and collaboration.

- The project plan includes collaboration with industry and the Risø National Lab doing modeling in Denmark.
- Feedback on the approach and project plan has evidently been received from only two companies.
- They are working with the H2A team at the National Renewable Energy Laboratory and Directed Technologies, Inc., and they are seeking input from various fuel cell developers as well as independent organizations that are active in installing demonstration units, such as Logan Energy.
- The project plans are excellent to share the model input-output with stakeholders.
- The project has good collaboration to date, but recommend talking to utility companies and perhaps US Fuel Cell Council

Question 5: Approach to and relevance of proposed future research

This project was rated **2.8** for proposed future work.

- Not Applicable.
- After nine (9) months of work on this project, the result should be an important component of the H2A model.
- There are no specific plans or proposals for follow-on work at this time.
- They mention applying the model to a wide variety of stationary applications, but no specific examples are given, and neither is any rationale for the selection of applications to study given.
- There was no discussion of any effort to optimize the mix of input energy sources, or of alternative energy conversion subsystems, to meet the electricity, heat, and hydrogen demands at lowest life-cycle cost.
- Tri generation (co-production of heat, power and hydrogen) is a very important option.
- The project has the appropriate next steps.

Strengths and weaknesses

Strengths

- For a relatively small expenditure, this project will support individuals/organizations in making decisions on investments in stationary power facilities.
- All of the recognized benefits of the H2A model (consistency, transparency, accepted costing methodology, etc.) will accrue to this project as well, since it will be fully integrated into the H2A model.
- The model is flexible in that additional modules, such as for photovoltaics or wind power, can be added relatively easily.
- The National Renewable Energy Laboratory team is very well qualified.
- Input from equipment supplier ensures the results.
- Good modeling work.

Weaknesses

- None.
- This work is based on hourly or seasonal energy and hydrogen demand profiles, which are not readily available for the variety of applications that would be of interest.
- There is no strategy to optimize the mix of input energy sources and the energy conversion devices in the model to achieve lowest life-cycle costs.
- Inadequate plan to identify externalities and approach to internalize them (e.g. emission trading, industrial uses, etc.)

Specific recommendations and additions or deletions to the work scope

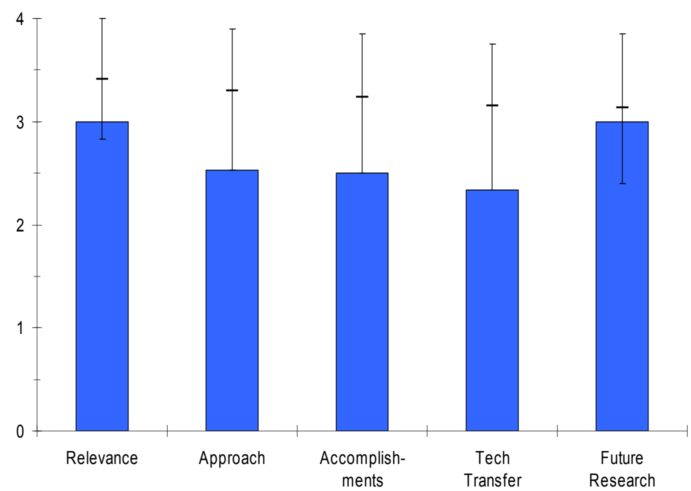
- Consideration should be given to a plan for disseminating the results to those who could productively employ this modeling tool.
- Consider optimization strategies for different scenarios. For example, consider these scenarios:
    - Different climatic regions.
    - Different mix and amounts of electricity, heat, and hydrogen.
    - Different costs (current, future) of the fuels, grid electricity, fuel cell systems (reformate and direct hydrogen) and renewable systems (photovoltaics, wind power).
    - Consider also the different sizes of the different fuel cells. For example, the high temperature fuel cells may be several hundred kW, the direct hydrogen fuel cells and electrolyzers may be only several to several tens of kW.
- The project should include all new opportunities to make positive impact on value proposition.
- The project should include renewable fuels.
- The project should include the impact of incentives (capital and O&M costs).

Project # ANP-04: Hydrogen Infrastructure Analyses
Anthony McDaniel; SNL

Brief Summary of Project

The objectives of this project are to 1) use dynamic models of interdependent infrastructure systems (natural gas, coal, electricity, petroleum, water, etc.) to analyze the impacts of widespread deployment of a hydrogen fueling infrastructure and 2) identify potential system-wide deficiencies that would otherwise hinder infrastructure evolution as well as mitigation strategies and unintended collateral effects on supporting systems. Sandia National Laboratories will provide analysis and insight into the dynamic behavior of complex systems and pose the following questions:

Overall Project Score: 2.6 (3 Reviews Received)



- Will the demand for steam methane reforming-derived hydrogen negatively impact natural gas distribution?
- Is there a potential for infrastructure interdependency issues to become problematic?
- Are there means to mitigate negative or amplify positive consequences?

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- The project goals and approach require additional development before the relevance can be fully determined.
- The concept for the project of gaining insights into the impact of hydrogen use on other systems, such as natural gas infrastructure is sound.
- Useful project to answer detractors who ask how much will hydrogen drive up the price of natural gas and other feedstocks.
- The project looks at potential critical infrastructure and natural gas supply issues during initial fuel cell vehicle roll-out.

Question 2: Approach to performing the research and development

This project was rated **2.5** on its approach.

- It seems that the initial funding is being applied to developing the project's methodology and approach.
- The Principal Investigator and the Sandia staff have the capability to accomplish modeling and analysis that effectively complements hydrogen-related analysis already supported by other organizations, particularly other national labs.
- The Sandia team still has work to do on developing and vetting the approach.
- Hydrogen vehicle adoption rate needs to be a function of more than just "advertising effectiveness" and hydrogen price. Adoption rate should include assumptions/scenarios for hydrogen vehicle cost and vehicle benefits/consumer preference (e.g., green house gas emissions reduction), among other inputs.
- Model results would be more defensible if they just considered hydrogen vehicle adoption rate a model input rather than trying to predict the future performance/cost of hydrogen vehicles and then OEM and consumer's response to the future product (too many uncertainties).

- A localized (southern California) look might not be best representative of the US demand. It might be true that initial fuel cell vehicle penetration in southern California decreases gasoline demand and drives down gasoline price. However, gasoline price overall in the US and in the world might not really go down.
- Need to consider the real effect on the current distribution pipelines to see whether these pipelines can adequately handle the increase in consumption from numerous natural gas reformer systems (central and forecourt combined).
- Need to consider social factors (greener hydrogen from natural gas through CO_2 sequestration, hybrid fuel cells, etc.), green house gas emission factor, and public's willingness to embrace these technologies (willingness to pay more).

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.5** based on accomplishments.

- Not Applicable.
- This project is just starting, but they appear to be making good progress.
- Project has only started about 6 months ago. Model needs more refinement to achieve more accuracy and granularity.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **2.3** for technology transfer and collaboration.

- Initiative should be taken to work more actively with other entities such as national laboratories, states (e.g., California) and industry which have a stake in the results.
- This should be done during the project development stage of what could be a long-term, high-cost project.
- Seems like this project could be better integrated with other hydrogen analysis studies being conducted (or completed), especially on hydrogen vehicle adoption.
- Too early to tell since project only started in December 2007. Looking to collaborate with universities is a good plan.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.0** for proposed future work.

- Not Applicable.
- Details of the initial project activity are still being developed.
- Good idea to incorporate water and electricity resources/capacities. Not sure how useful it is to roll this out to the rest of the country just yet.
- Factoring in electricity demand is a good plan since the majority of electricity produced in California is from natural gas.
- Might need to factor in potential spikes in natural gas price due to demand (locally, nationally and globally). This might to be disruptive (higher gas price = higher hydrogen price = fuel cell vehicle less attractive).
- Need to consider scenario of decreased gasoline demand in southern California might lead to decreased industrial gas demand (refineries no longer need as much natural gas to produce hydrogen for gasoline production). The increased natural gas demand by fuel cell vehicle roll-out might be offset (partially) by the decreased in industrial gas usage.

Strengths and weaknesses

Strengths
- With the right team, approach and collaborations, this project could help fill a current gap in the hydrogen systems analysis program element.
- Provides a picture of what we need to be considered from the fuel and infrastructure standpoint (potential disruptive issues) during initial local fuel cell vehicle roll-out.

Weaknesses

- Sandia staff needs to work intensively with others having a stake in the results during early project development to get feedback, recommendations and buy-in.
- The project needs further refinement because the project has too many assumptions and uncertainties at this point of the project.

Specific recommendations and additions or deletions to the work scope

- Why is this project ending in 2015? Project budget and scope in future work should be complete by FY09.